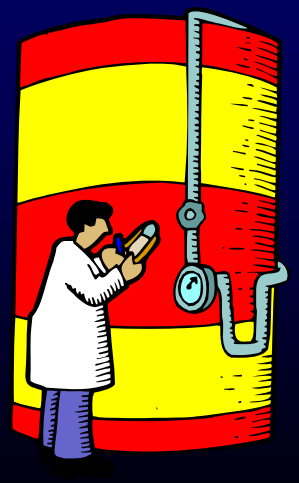
Process Hazard Analysis and Hazard Review

Process Hazard Analysis (PHA)

- Systematic approach to identify, evaluate and control potential process hazards
- Provides info to help make decisions on improving safety & reducing consequences of releases
- Analyzes potential causes and consequences of fire, explosions, and hazardous chemical releases
- Focuses on equipment, instrumentation, utilities, human factors, and other external factors that may affect the process

When is a PHA/HR needed?

- Concept development, design, start-up, operation, modifications, decommissioning, or demolition
- Update at least every five years or when process changes



Who is involved?

- Team effort
- Identify team members; titles & areas of expertise
- Identify team leader; description of experience

Hazard Analysis Process

Hazards Identification

- Chemical Identity
- Quantity
- Location
- Nature of the Hazard

Vulnerability Analysis

- Vulnerable Zone
- Human Populations
- Critical Facilities
- Environment

Risk Analysis

- Likelihood of a Release Occurring
- Severity of the Consequences

Hazards Identification for PHA/HR

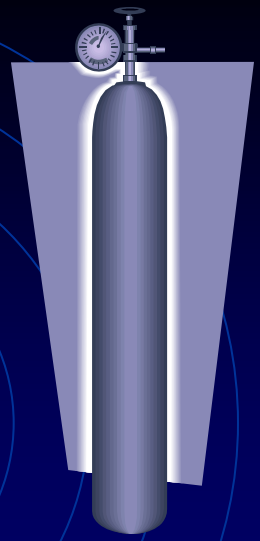
- Unsafe acts or conditions that create the potential for an accident
- Loss of containment of flammable, combustible, highly reactive, or toxic materials
- Uncontrolled electrical hazards or mechanical overpressure

Hazards Identification for PHA/HR

Hazards Identification

- Process materials
- Process conditions
- Siting & Plant layout
- Equipment
- Control system
- Standard operating procedures
- Emergency plans
- Test, inspection, and maintenance practices
- Protective measures
- Operator training
- Management attention
- Staff attitudes
- Contract Labor

Hazards Identification
Causes of Accidents



1. Equipment Failure
2. Human Error - 85%
   - 10% personal influences -emotional state, health, or carelessness
   - 75% external influences -deficient procedures, inadequate supervision, poor work environment, ineffective training, or insufficient staffing
3. External Events
   - Natural events -flooding, earthquake
   - Human-induced -dropped object, vehicle impacts
   - Utility failure

Hazards Identification
Potential Sources of Data

- Fire department & building inspection records
- Industrial questionnaires
  - Chemical Manufacturers Association
  - IIAR
- Chemical property databases or other references
  - NIOSH Pocket Guide to Chemical Hazards (www..cdc.gov/niosh)
  - MERCK database
  - Emergency Response Guide

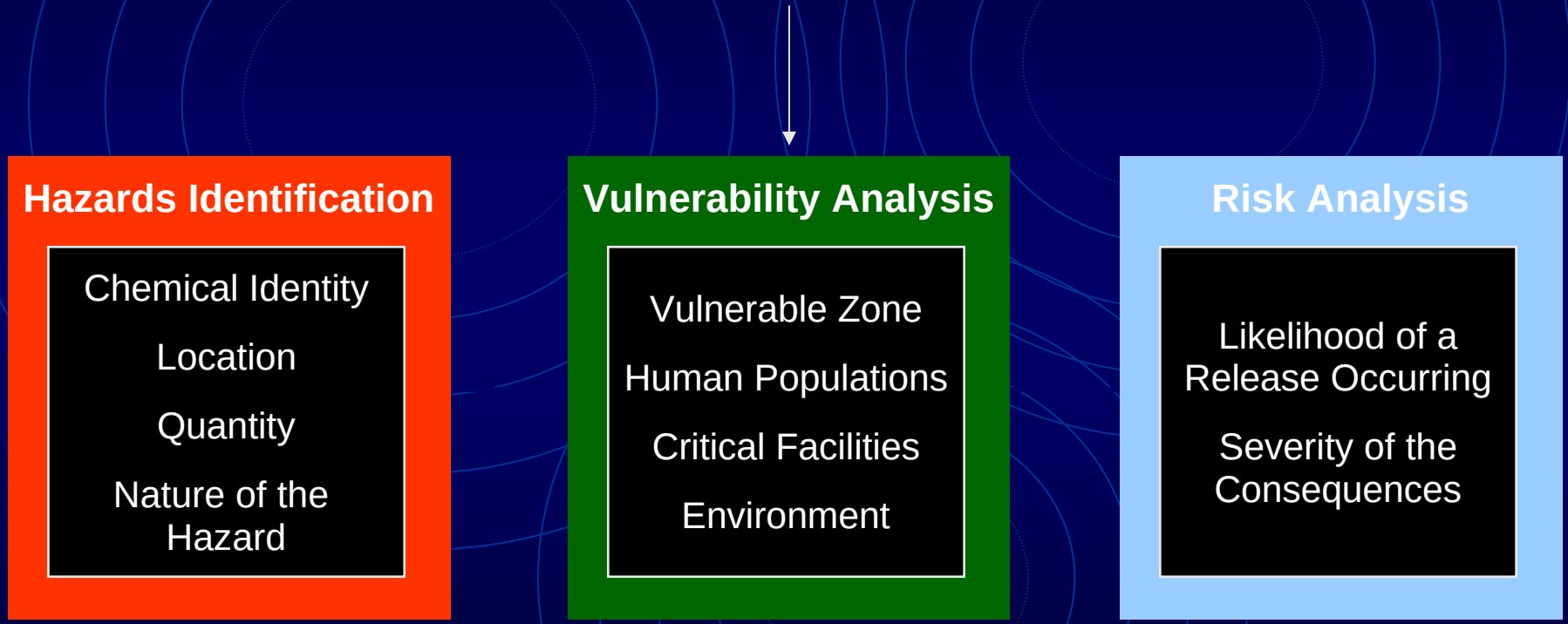
Initial Hazard Identification

Initial Screening	Hazard A	Hazard B	Hazard C
Chemical	Chlorine	Ammonia	Liquid methyl isocyanate (MIC)
Location	Storage tank at water treatment plant	Tank truck on local highway	Pesticide manufacturing plant in nearby semi-rural area
Quantity	10 kg	2500 kg	2500 kg
Properties	Poisonous; may be fatal if inhaled. Respiratory conditions aggravated by exposure. Contact may cause burns to skin and eyes. Corrosive. Effects may be delayed.	Poisonous; may be fatal if inhaled. Vapors cause irritation of eyes and respiratory tract. Liquid will burn skin and eyes. Contact with liquid may cause freezing of skin. Effects may be delayed. Will burn within certain vapor concentration limits and increase fire hazard in the presence of oil or other combustible materials.	Causes death by respiratory distress after inhalation. Other health effects would include permanent eye damage, respiratory distress, and disorientation. Explosive. Extremely flammable.

Reevaluated Hazard Identification

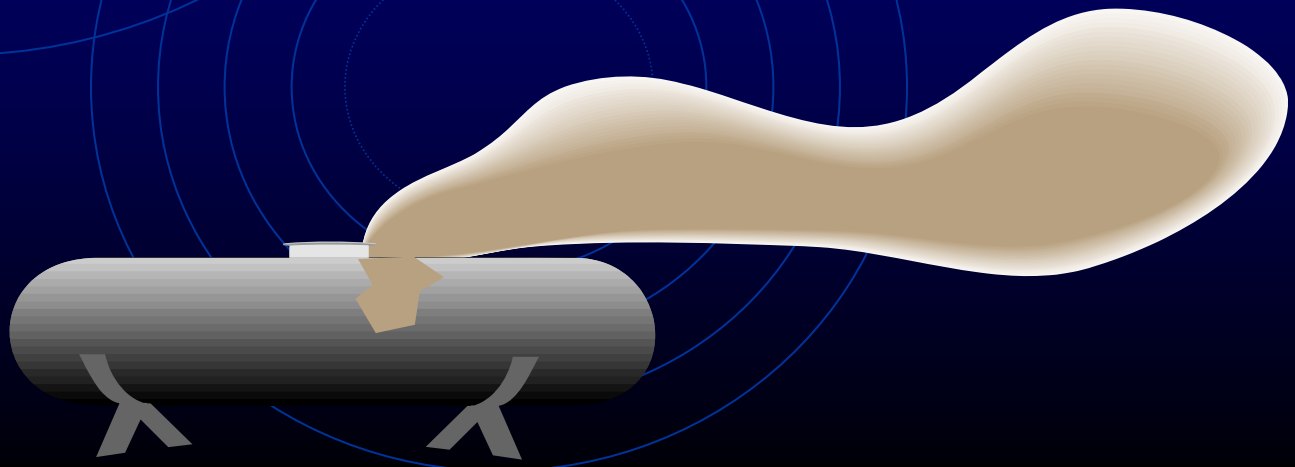
Reevaluation	Hazard A	Hazard B	Hazard C
Chemical	Chlorine	Ammonia	Liquid methyl isocyanate (MIC)
Location	No change	No change	No change
Quantity	500 kg (decrease due to actual quantity used)	No change	3000 kg (increase due to production changes)
Properties	No change	No change	No change

Hazard Analysis Process for PHA



Vulnerability Analysis

- Potentially impacted area (vulnerable zone)
  - Population
  - Environmentally sensitive areas
  - Public and private property



Vulnerability Analysis
Determination of Vulnerable Zone

- Simple
  - Screening analysis using CAMEO
  - References such as standardized tables
    - US Technical Guidance for Hazardous Anaylsis
- Complex
  - Dispersion modeling for identified hazards using computer software such as ALOHA

Vulnerability Analysis Factors

- Total quantity of chemical
- Physical state of chemical
  - solid, liquid or gas
- Chemical properties
  - vapor pressure, boiling point, density relative to air
- Meteorological conditions
  - wind speed/direction, atmospheric stability

Vulnerability Analysis Factors

- Surrounding topography
  - urban vs. rural, large physical obstructions
- Levels of Concern (LOC)
  - Chemical concentration above which there may be serious health effects or death
  - overpressure that would result in significant damage to surrounding structures

Vulnerability Analysis
Sources for LOC

- National Institute of Occupational Safety and Health - Immediately Dangerous to Life and Health (NIOSH IDLH)
  - www.cdc.gov/niosh
- American Conference of Governmental Industrial Hygienists - Threshold Limits Values (ACGIH TLV)

Vulnerability Analysis Sources for LOC

- Emergency Response Planning Guidelines
  - ERPG-3: Max airborne conc below which most people could be exposed to for ≤ one hr w/out **life-threatening** health effects
  - ERPG-2: Max airborne conc below which most people could be exposed to for ≤ one hr w/out **serious health effects**
  - ERPG-1: Max airborne conc below which most people could be exposed to for ≤ one hr with **mild transient health effects**

Vulnerability Analysis
Prioritization of Hazards

- Vulnerability zones for all facilities and potential transportation incidents evaluated using credible worst case assumptions
- Alternate case assumptions may used for high priority facilities or transportation incident scenarios
- Vulnerability zones may increase or decrease based on alternate case assumptions

Vulnerability Analysis Environmental Sensitivities

- Sensitive habitat and species w/in the vulnerable zone
  - wetland/estuary habitats
  - bird nesting colonies
  - threatened, endangered, or otherwise protected species

Vulnerability Analysis
Human Populations

- Property uses w/in the vulnerable zone
  - Homes, businesses, offices, other facilities
  - Water, power, & food supply systems
  - Medical facilities
  - Essential transportation corridors

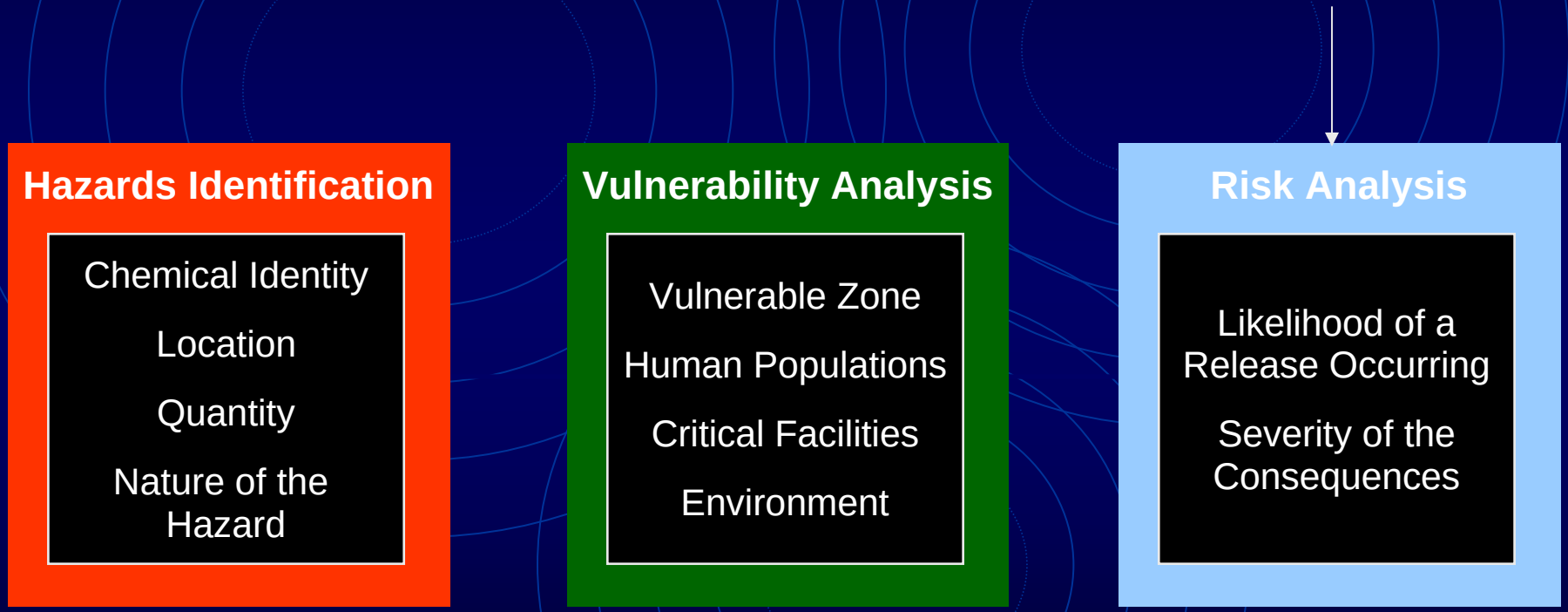
Initial Vulnerability Analysis

Initial Screening	Hazard A (chlorine)	Hazard B (ammonia)	Hazard C (methyl isocyanate – MIC)
Vulnerable zone	Radius 5 km where chlorine gas may exceed the level of concern.	Radius 4 km where ammonia exceeds the level of concern.	Radius 10 km with MIC vapors exceeding the level of concern
Population within vulnerable zone	Approximately 500 residents of a nursing home; 50 workers at a small factory.	Up to 700 persons in residences, businesses, or other vehicles. Seasonal influx of visitors to nearby forest preserve.	Up to 200 workers at the plant, rural area with 85 people per square km (15,400), 1000 children in nearby school.
Private and public property within vulnerable zone	Facility equipment and structures, 2 fire stations and 1 hospital	25 residences , 2 restaurants, a hotel, gas station, and market. Vehicles and effect on traffic flow.	Runoff to sewer may cause explosion due to MIC reactivity with water.
Environment within vulnerable zone	Terrestrial (land-dwelling) wildlife	Adjacent forest preserve is highly susceptible to fires.	Nearby nesting eagles.

Reevaluated Vulnerability Analysis

Reevaluation	Hazard A (chlorine)	Hazard B (ammonia)	Hazard C (methyl isocyanate – MIC)
Vulnerable zone	Zone decreases to radius 2 km due to decreased quantity and use of urban dispersion model	No change	Zone increases to a radius of 15 km due to increased production
Population within vulnerable zone	Decreases because nursing home no longer within vulnerable zone. 50 workers at a small factory.	No change	Increases due to larger vulnerable zone. Up to 200 workers at the plant, rural area with 85 people per square km (20,000), 1000 children in nearby school.
Private and public property within vulnerable zone	Facility equipment and structures	No change	Runoff to sewer may cause explosion due to MIC reactivity with water; 1 fire station; and 1 police station
Environment within vulnerable zone	None	No change	Nearby nesting eagles.

Hazard Analysis Process for PHA



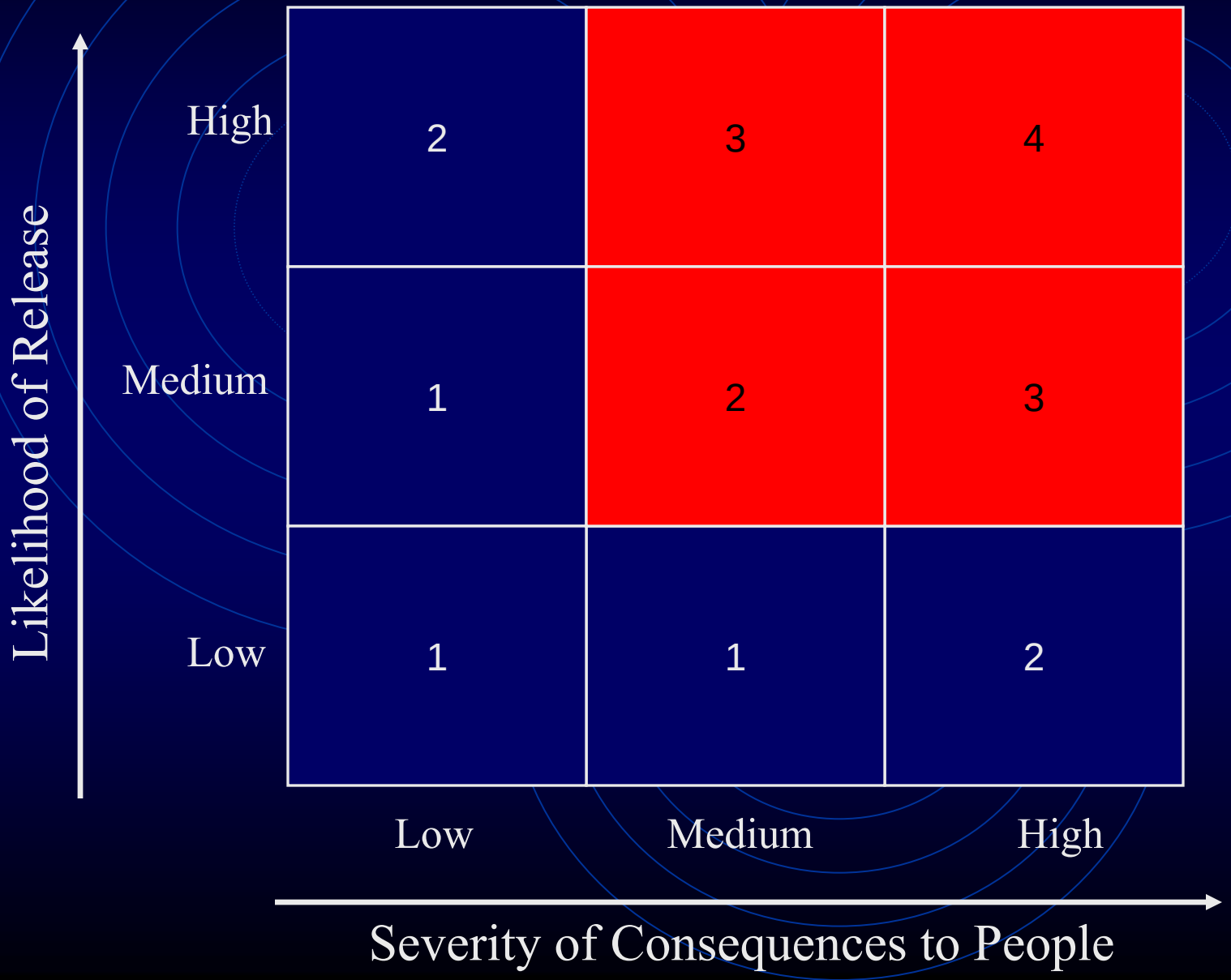
Risk Analysis
Likelihood of Occurrence

Low	Probability of occurrence considered **unlikely** during the expected lifetime of the facility assuming normal operation and maintenance
Medium	Probability of occurrence considered **possible** during the expected lifetime of the facility
High	Probability of occurrence considered sufficiently high to assume the event **will occur** at least once during the expected lifetime of the facility

Risk Analysis
Severity of Consequences

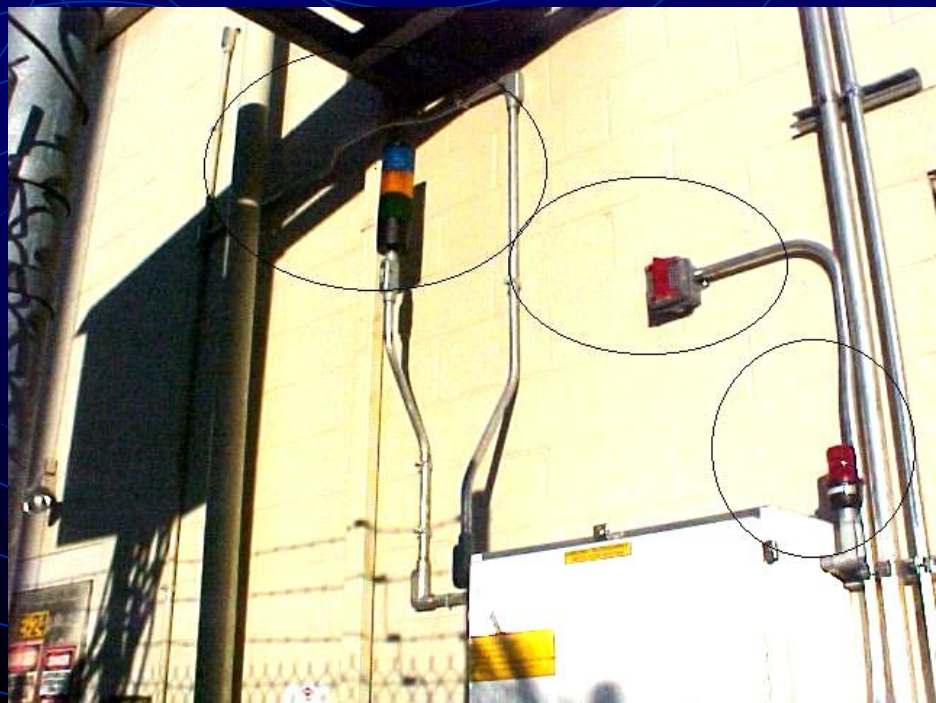
Low	Chemical is expected to move into the surrounding environment in negligible concentrations. Injuries expected only for exposure over extended periods or when individual personal health conditions create complications.
Medium	Chemical is expected to move into the surrounding environment in concentrations sufficient to cause serious injuries and/or deaths unless prompt and effective corrective action is taken. Death and/or injuries expected only for exposure over extended periods or when individual personal health conditions create complications.
High	Chemical is expected to move into the surrounding environment in concentrations sufficient to cause serious injuries and/or deaths upon exposure. Large numbers of people expected to be affected.

Risk Analysis Matrix



Risk Analysis
Required Information

- Hazards identifications and vulnerability analysis
- Records of past incidents and outcomes
- Local response capabilities
- Facility & community plans and safeguards
- Detection or monitoring measures
- Release prevention measures



Initial Risk Analysis

Initial Screening	**Hazard A** Chlorine storage tank	**Hazard B** Ammonia tanker truck	**Hazard C** Pesticide (MIC) manufacturer
Risk Relative to other facilities in planning area	High	Medium	High

Reevaluated Risk Analysis

Reevaluation	Hazard A (chlorine)	Hazard B (ammonia)	Hazard C (MIC)
Probability of hazard occurrence	LOW—because chlorine is stored in an area with leak detection equipment in 24-hour service with alarms.	HIGH—Highway area has a history of accidents due to poor visibility.	LOW—facility has up-to-date containment facilities with leak detection equipment and an emergency plan for employees.
Consequences if people are exposed	High levels of chlorine gas in the nursing home and factory could cause death and respiratory distress.	Release of vapors and subsequent fire could cause other accidents. Injured or trapped motorists subject to lethal vapors. Windblown vapors can cause respiratory distress for nearby residents and businesses.	If accident occurs while school is in session, children could be killed, blinded, and/or suffer chronic respiratory problems. Plant workers subject to similar effects.
Consequences for property	Possibility of superficial damage to equipment and structures due to corrosive fumes.	Repairable damage to highway. Potential destruction of nearby vehicles due to fire/explosion.	Vapors may explode in a confined space causing property damage. Possible damage from fires.
Consequences for environment	Possible destruction of surrounding plant and animal life.	Potential for fire damage to adjacent forest preserve.	Eagles could be killed or their habitat destroyed.
Summary: Likelihood of occurrence/severity of consequences	Low/High. The community should assess this on a site and incident specific basis.	High/High. The community should assess this on a site and incident specific basis.	Low/High medium. The community should assess this on a site and incident specific basis.

PHA methodologies

Checklist:

- Simple “cookie-cutter facilities”
- Example: propane backup gas systems

What-If?/Checklist:

- Facilities with “stock” elements custom engineered and sited
- Most ammonia refrigeration facilities

HAZOP

- Complicated facilities, unfamiliar technology
- Skilled teams at complex refrigerated facilities

Table 1: Applicability of PHA Techniques (ref: AIChE)

Particular Phases in Process Design and Operation	Checklist	What-if	What-if/ Checklist	HAZOP	FMEA	FTA
R&D		✓				
Design	✓	✓	✓			
Pilot Plant Operation	✓	✓	✓	✓	✓	✓
Detailed Engineering	✓	✓	✓	✓	✓	✓
Construction/Startup	✓	✓	✓			
Routine Operation	✓	✓	✓	✓	✓	✓
Modification	✓	✓	✓	✓	✓	✓
Incident Investigation		✓		✓	✓	✓
Decommissioning	✓	✓	✓			

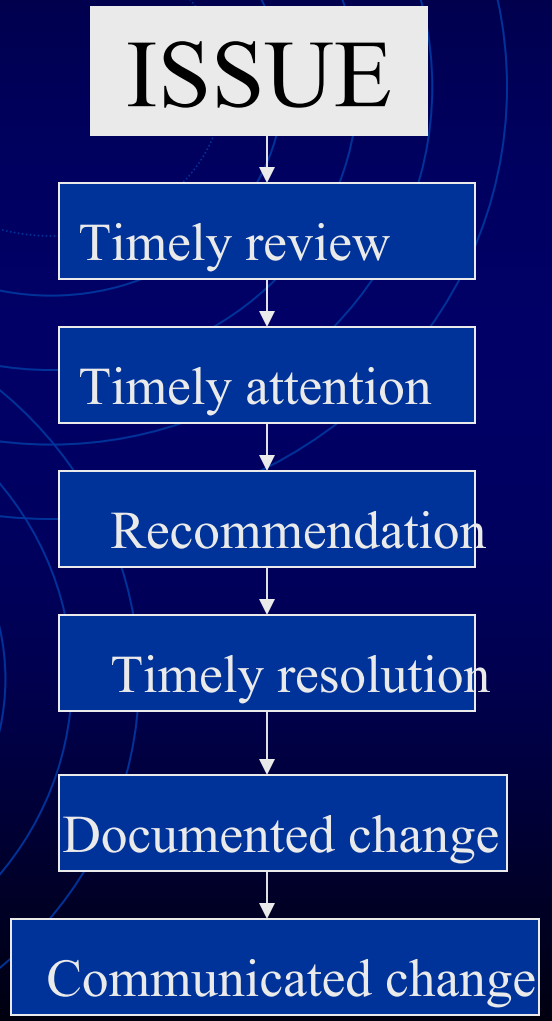
Table 2: Time and Staffing for PHA Techniques (ref: AIChE)

Various Steps	Checklist	What-if	What-if/ Checklist	HAZOP	FMEA	FTA
Simple/Small System						
# Staff	1-2	2-3	2-3	3-4	1-2	2-3
Preparation	2-4 h	4-8 h	6-12 h	8-12 h	2-6 h	1-3 d
Modeling						3-6 d
Evaluation	4-8 h	1-3 d	6-12 h	1-3 d	1-3 d	2-4 d
Documentation	4-8 h	1-2 d	4-8 h	2-6 d	1-3 d	3-5 d
Large/Complex Process						
# Staff	1-2	3-5	3-5h	5-7	2-4	2-5
Preparation (hours)	1-3 d	1-3 d	1-3 d	2-4 d	1-3 d	4-6 d
Modeling						2-3 w
Evaluation	3-5 d	4-7 d	4-7 d	1-3 w	1-3 w	1-4 w
Documentation	2-4 d	4-7 d	1-3 w	2-6 w	2-4 w	3-5 w

d = days; h = hours; w = weeks

PHA/HR Report

- Findings and recommendations documented
- Recommendations **assigned** and given a (timely) **due date**
- Resolution of recommendations fully documented
- Report & resolutions provided to appropriate personnel
- Issues resolved before startup of a changed process
- Reports retained for the life of the process

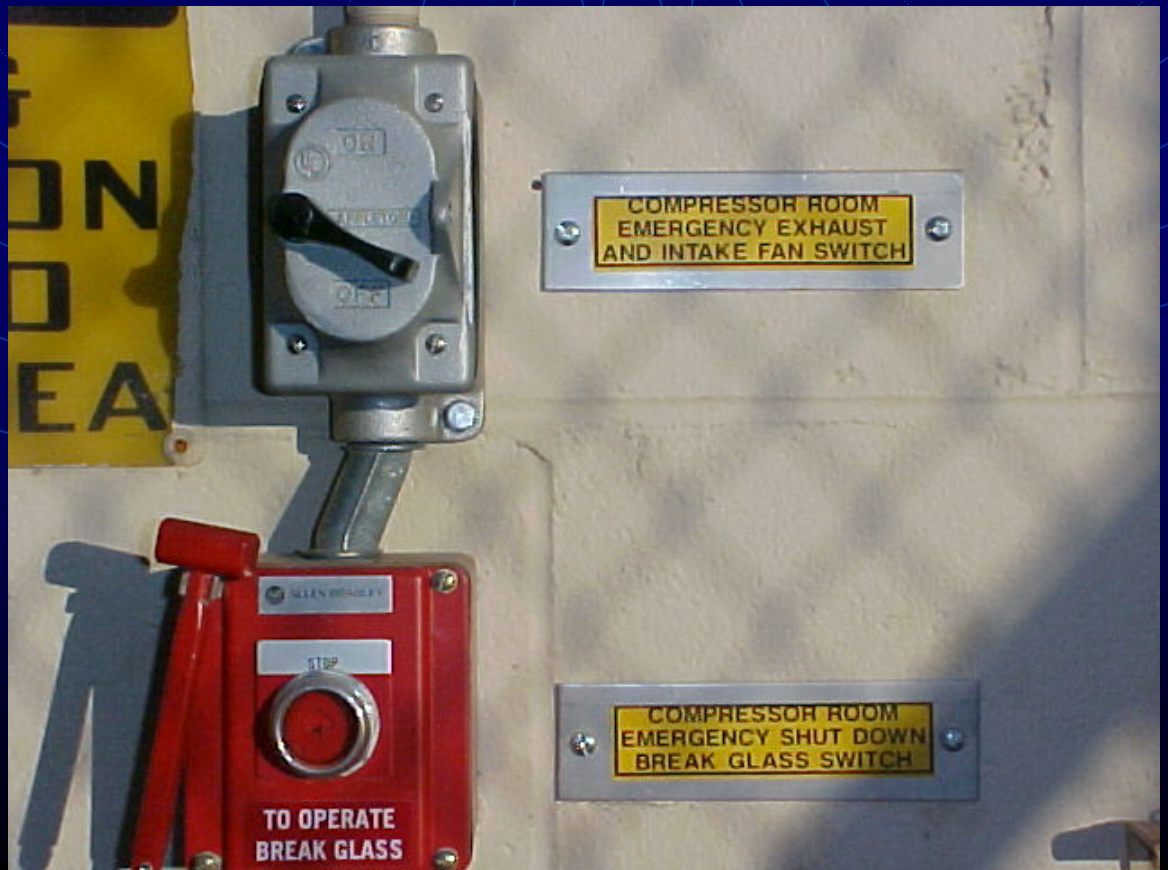


Methods to Manage Risk

- **Location of new plants**
- **Type and quantity of hazardous materials**
- **Eliminate discharges**
- **Types of plant operations**

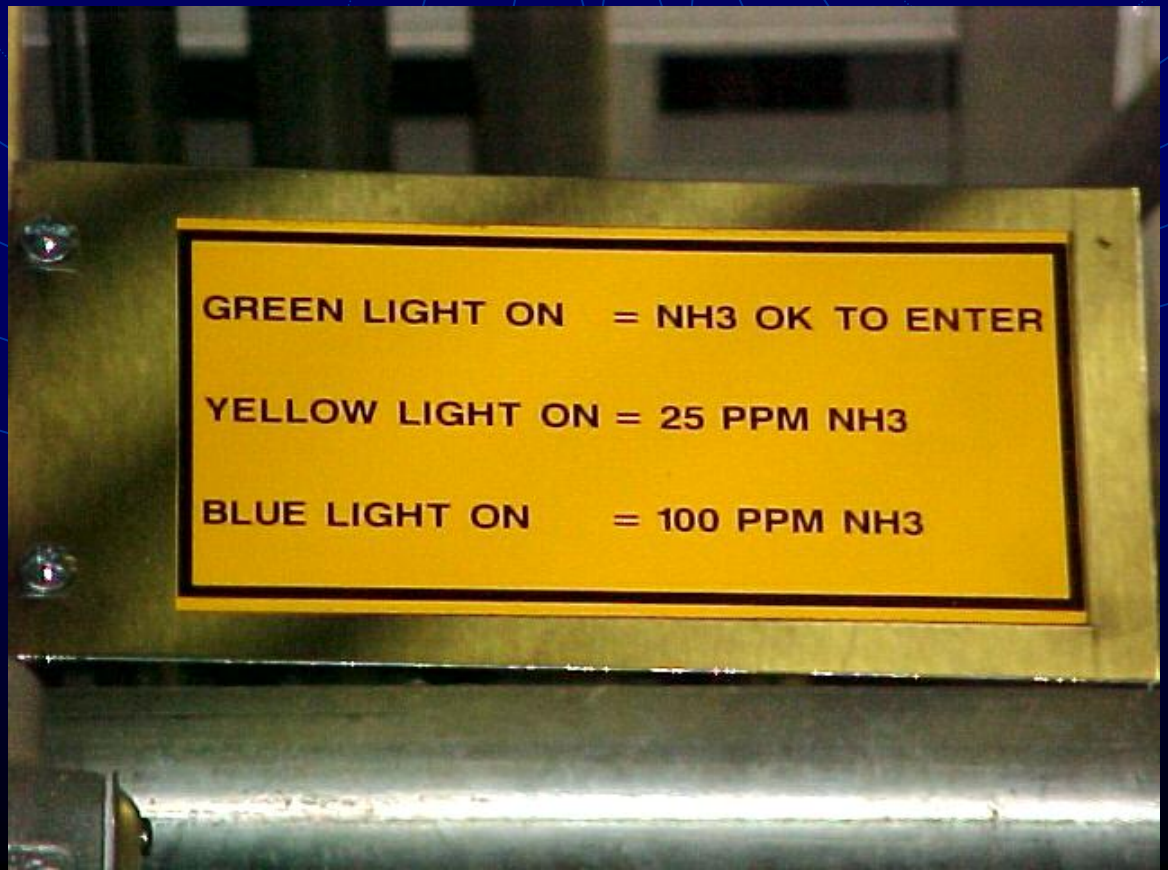
Methods to Manage Risk

- **Safety measures to limit exposure/releases**



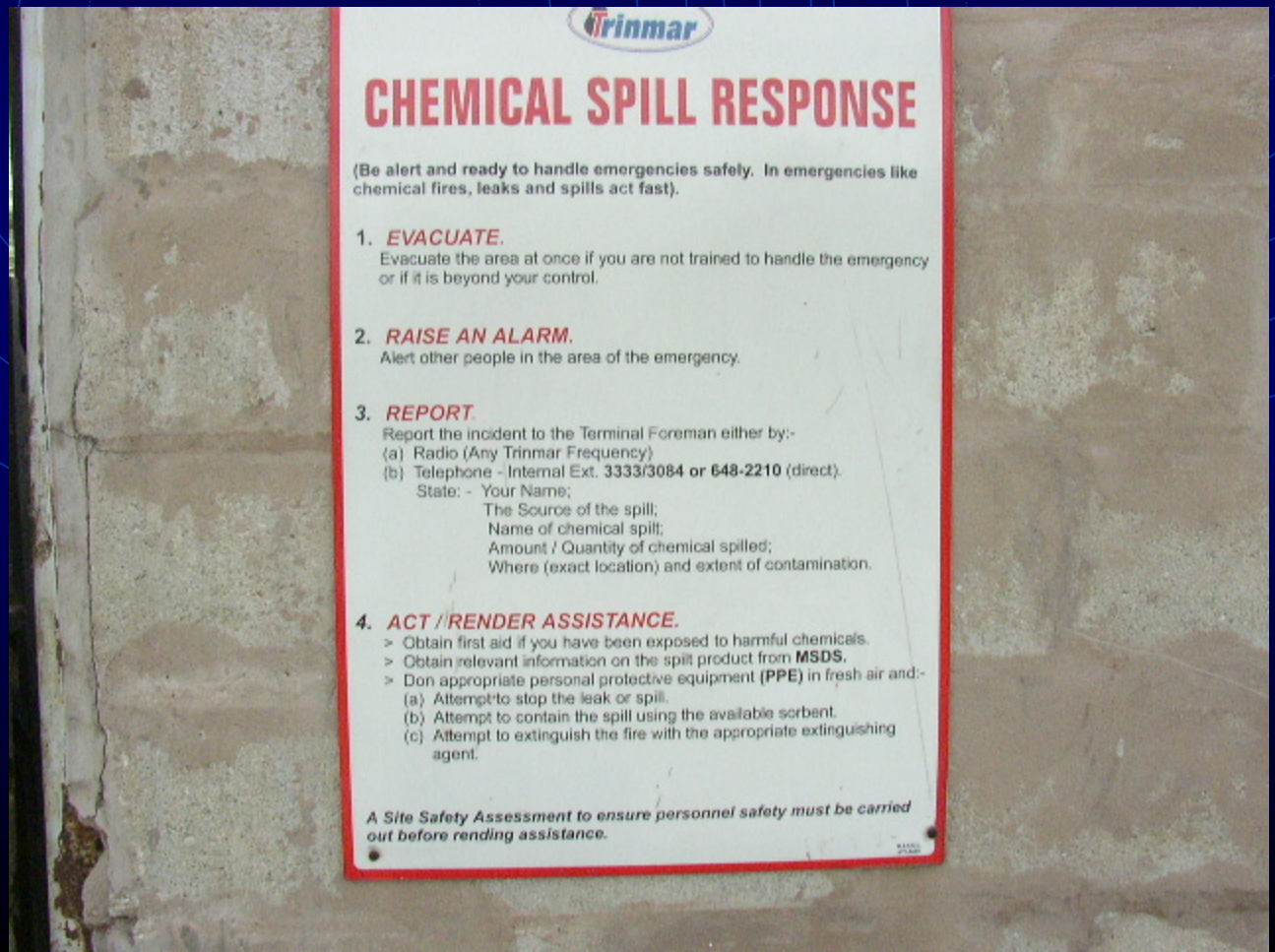
Methods to Manage Risk

- **Safety measures to limit exposure**



Methods to Manage Risk

- **Emergency response planning**



Methods to Manage Risk

- **Security**